

EVIDENCE FOR EXTENDED AQUEOUS ALTERATION IN CR CARBONACEOUS CHONDRITES.

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Introduction: We are currently studying the chemical interrelationships between the main rock-forming components of carbonaceous chondrites (hereafter CC), e.g. silicate chondrules, refractory inclusions and metal grains, and the surrounding meteorite matrices. It is thought that the fine-grained materials that form CC matrices are representing samples of relatively unprocessed protoplanetary disk materials [1-3]. In fact, modern non-destructive analytical techniques have shown that CC matrices host a large diversity of stellar grains from many distinguishable stellar sources [4]. Aqueous alteration has played a role in homogenizing the isotopic content that allows the identification of presolar grains [5]. On the other hand, detailed analytical techniques have found that the aqueously-altered CR, CM and CI chondrite groups contain matrices in which the organic matter has experienced significant processing concomitant to the formation of clays and other minerals. In this sense, clays have been found to be directly associated with complex organics [6, 7]. CR chondrites are particularly relevant in this context as this chondrite group contains abundant metal grains in the interstitial matrix, and inside glassy silicate chondrules. It is important because CR are known for exhibiting a large complexity of organic compounds [8-10], and only metallic Fe is considered essential in Fischer-Tropsch catalysis of organics [11-13]. Therefore, CR chondrites can be considered primitive materials capable to provide clues on the role played by aqueous alteration in the chemical evolution of their parent asteroid.

Technical procedure: Thin sections of 3 pristine Antarctic CR chondrites (EET 92159, GRA 95229, and LAP02342) provided by the NASA Johnson Space Center were studied together with the Kaidun microbreccia meteorite [14-15]. Despite being a complex meteorite, mainly a mix between CC and enstatite chondrites Kaidun is relevant to our discussion of parent body alteration. Aqueous alteration features of the Antarctic CRs were compared with Kaidun as the later represents a recent fall that has also experienced similar degree of aqueous alteration. First, high-resolution mosaics of the CR sections were generated from separate 100X images taken with a Zeiss Scope petrographic microscope. The mosaics allowed us to study the different lithologies and establish features to be

characterized by more sophisticated micro-Raman, ambient SEM, and EDS techniques. We used a FEI Quanta 650 FEG working in low vacuum BSED mode. The EDS detector used was an Inca 250 SSD XMax20 with an active area of 20 mm². The previously selected areas were explored at different magnification, and SEM elemental mapping was performed of the key areas to understand parent body aqueous alteration.

Results and discussion: Some minerals in the CR chondrites group have experienced aqueous alteration. Many of their components are highly unequilibrated like we expect from primitive materials that have experienced a low degree of metamorphism. Mild thermal metamorphism is the cause of significant modification of the troilite (FeS) content by remobilizing sulfides into larger grains [16]. In CR chondrites most of the chondrules contain metal grains and troilite that, when exposed to aqueous alteration, are altered. The Fe and S mobilization through the chondrule walls produces sulphide-rich rims surrounding the chondrules (as shown in EDS spectrum of Fig. 1). Such regions are interesting to us because they are associated with C-rich regions of the CR chondrites matrices.

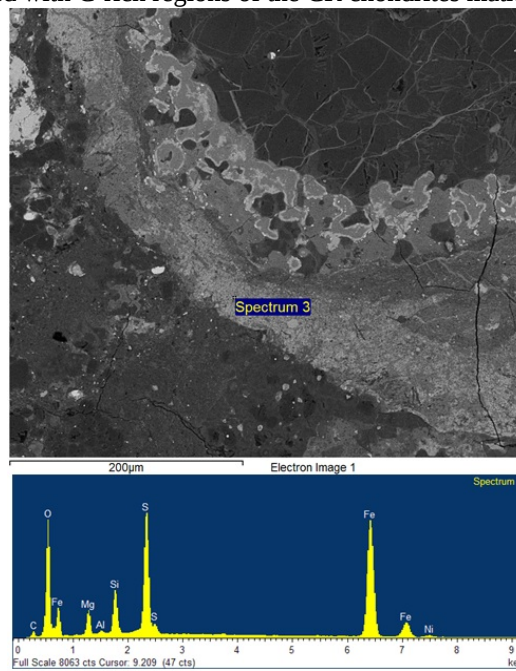


Figure 1. A sulphide-rich rim surrounding a chondrule of CR2 chondrite LAP 02342.

As previously found for CM chondrites [17], water played a major role in mobilizing certain elements initially present in the interiors of chondrules, sulfides, and metal grains of CR chondrites. The action of water in some cases was extremely pervasive, and participated in the complete replacement of mineral grains located in the matrix. In this sense, we have found clear evidence of pyrrhotite replacement by aqueous altered minerals in GRA 95229 and EET 92159. The voids left by such replacing are partially filled by sub-micron-sized magnetite. In some cases the replacement is not complete and some pyrrhotite can be found. Interestingly, such growth of magnetite is expected to occur from the precipitation of Fe from a low-temperature aqueous solution (Fig. 2).

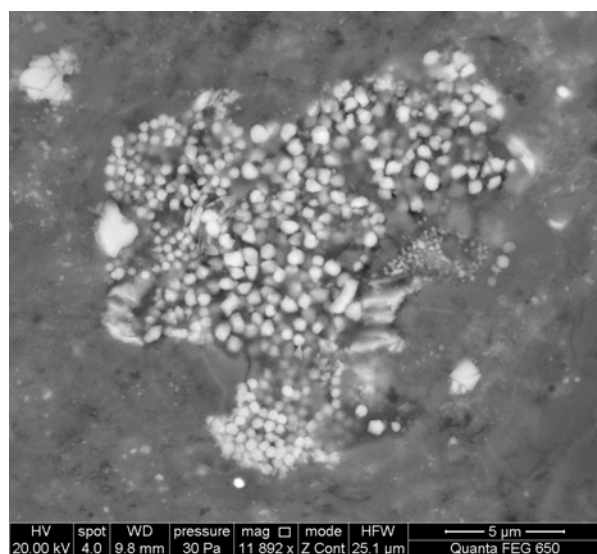


Figure 2. The L6e region of GRA 95229 exhibits this matrix pore filled by magnetite grains.

Interestingly, a similar action of water on pyrrhotite grains has been observed by one of us (MZ) in the Kaidun meteorite. This result is nicely exemplified in Fig. 3 that can be directly compared with previous Fig. 2. Kaidun was quickly recovered after its fall in South Yemen in 1980, but exhibits similar aqueous alteration minerals. Consequently, our work supports the importance of water in the chemical processing of the CR parent asteroid. In future work, we plan to explore by other techniques the interrelationships among these aqueous alteration minerals, and the carbonaceous materials associated with the matrix.

Conclusions: The observed mineralogy of the studied CR chondrites is suggesting parent body aqueous alteration processes. The CR parent asteroid was soaked in water enough time to produce the observed

sulphide rims and magnetite as aqueous alteration products.

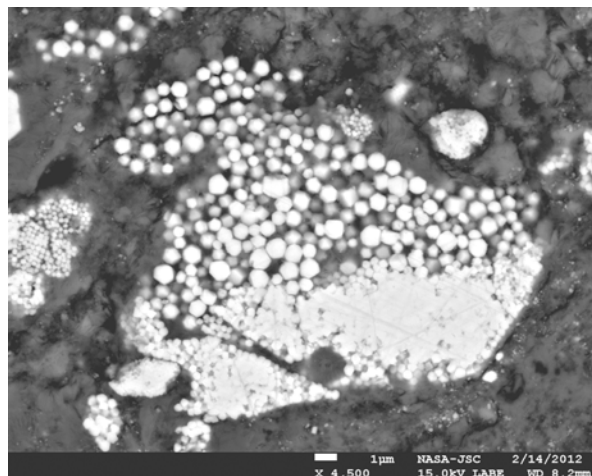


Figure 3. Kaidun also exhibits magnetite grains filling the voids left by primordial pyrrhotite grains.

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